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Elemental Analysis of Ash using X-Ray Fluorescence Technique

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In thermal plants, when pulverized coal is burnt to generate heat, the residue contains 80 per cent fly ash and 20 per cent bottom ash. The ash is carried away through chimney and collected at economizer, air pre-heater and electrostatic precipitator (ESP) hoppers. We analyze the coal fly ash samples by using X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) techniques. In the present analysis, we observed that the major elements present in the ash samples are Si, Al & Fe and the other minor constituents are Ti, P, S, Mg, Cl, K, Ca, Zn & Sr. The elemental analysis of these samples will be informative to use the fly ash for various applications such as cement manufacturing, ceramic production and as a secondary source in recovery of valuable elements.

Key Words: Fly ash, XRF, XRD, Thermal power plant, Elemental analysis.

INTRODUCTION

One of the major problems in our country is disposed of a large amount of coal fly ash from thermal power plants which affect our environment and water resources. Especially, in state where the population density is high and space for land filling is limited poses a serious problem. Our nation's electricity comes from four main sources: Coal, nuclear, natural gas, and hydroelectric. Power plants fueled by coal generate slightly more than half of the nation's electric power today. Approximately 260 million ton of coal is consumed per annum by 82 utility thermal power plants in India which in turn, produced 108 million ton of fly ash per year[1]. In India every year, large quantities of industrial by products are also produced by chemical and other industrial process like ceramic pottery industries etc. This large amount of fly ash occupies large area of land and possesses threat to environment. As such, there is urgent and imperative need to adapt technologies for gainful utilization and safe management of fly ashes on sustainable basis.

Fly ash is a fine, powdery material that is produced by burning coal to produce electricity. When coal is used in a power plant, it is first ground into a very fine powder and blown into the power plant's boiler. Carbon and hydrogen in the coal are consumed, leaving noncombustible molten particles rich in silica, alumina and etc. These particles solidify as fly ash and being very fine powder tends to travel in the air[2]. If these fly ash particles do not properly disposed then it pollutes air and water and causes respiratory problems. Moreover, if this fly ash settles on leaves and crops in agriculture fields around the power plant, it lowers the yield.

Fly ash helps to conserve natural resources by replacing materials and environmental impact which would otherwise be caused by mining these resources. Additionally, cement manufacturing is a major contributor of carbon dioxide emissions to the atmosphere. Reducing cement production reduces greenhouse gas emissions on almost a ton for ton basis. For each ton of cement production a ton of CO_2 is emitted. By replacing a ton of cement production with a ton of fly ash that emission of CO_2 is eliminated. If all of the fly ash produced in our country each year were used to replace cement in producing concrete, road construction and ponds construction, the reduction in carbon dioxide released because of decreased cement production would be equivalent to eliminating 25 percent of the world's motor vehicles[2].

It is recognized that health hazards and environmental impact from thermal power plants result from the mobilization of toxic and radioactive elements from the residues which, in turn, depends on metrological parameters. The characterization of fly ash, its potential for use and potential hazards to plants and animals were reviewed by Adriano et al [3].

The Government of India, through the department of Science and Technology, has initiated the fly ash mission, under Technology Information and Assessment Council (TIFAC). The mission propagates various developments in the area of Fly ash utilization carried out by R & D institutes in India. The Fly ash mission was commissioned in 1994 with the Department of Science & Technology (DST) as the nodal agency and TIFAC as the implementing agency, in view of the overall concern for the environment and the need for the safe disposal and effective utilization of fly ash[4].

X-ray fluorescence technique is a non-destructive method for the elemental analysis[5]. It is one of the most popular methods for quantitative analysis. XRF is fast, economical and fully suitable for simultaneous quantitative determinations of matrix elements from Fluorine to Uranium [6-7]. Therefore, it presents some advantages over other spectrometric methods like Neutron Activation Analysis (NAA); which is expensive and not widely available, inductively coupled plasma atomic emission spectroscopy (ICP-AES); which requires dissolution procedures, and are generally time consuming and can induce losses of some volatile elements. Therefore X-ray fluorescence instrumentation has lower capital cost and cheaper than to use than NAA, ICP- AES and is widely available[8-10].

In the present work we have analyzed fly ash samples from Deen Bhandu chhotu Ram, Yamuna Nagar; Thermal Power Plant, Panipat, Haryana and Ceramics Pottery Industry, Khurja, Bulandshahr U.P.

EXPERIMENTAL

The fly ash samples were collected from Deen Bhandu Chhotu Ram, Yamuna Nagar, Panipant Thermal Power Plant, Haryana and Ceramics Pottery Industries, Khurja, Bulandshahr U.P. from different locations i.e. from electrostatic precipitator (ESP), bottom ash and slurry. The slurry samples were dried in an oven at 100 ^{0}C. Then all these samples were grinds in a fine powder form by using INSMART Planetary Micro Milling systems. It was not possible to made pellets (required for XRF system) for fine dry powder. Therefore, we mix cellulose as binder with ash samples in weight ratio of 1:9 grams and then pellets were made by using Motorized Pellet Press, Kimaya Engineers. These samples/pellets were then analyzed using XRF Rigaku, mini desktop system. It is of 40 KV X-ray tube (50 W) end window type with a single target (Pd); having hard excitation efficiency for heavy and light elements (F to U). The experimental error is approximately of the order of 3 % in all the analysis using XRF technique. We also analyze the powder form of these samples using XRD technique.

RESULTS AND DISCUSSION

The samples of fly ash, bottom ash and slurry of different thermal power plants and pottery industry were analyzed by XRF and XRD and the compositions of several elements present in the samples were determined. In all Fly ash samples, the major components are Si, Al and Fe but iron concentration is more in Pottery ash (Khurja) sample as compared to thermal power plants samples. The other elements Ti, P, S, Mg, Cl, K, Ca, Fe, Zn and Sr, occur as minor constituents in the samples. Table 1 represents the elemental composition in all the ash samples collected from the Deen Bhandu Chhotu Ram (Yamuna Nagar), the Panipant Thermal Power Plant (Panipat), Haryana and Ceramics Pottery Industry, Khurja, Bulandshahr, U.P.

The X-ray diffraction (XRD) patterns for the fly ash, bottom ash and slurry samples are shown in Figure 3. The XRD patterns also supports the X.R.F. results that the major phases in fly ash, bottom ash and slurry samples are silicon, aluminum and iron oxides.

Table 1. Elemental composition of collected ash samples.

S. No	Component	Elemental composition of ash samples				
		Deen Bhandu chhotu Ram Thermal power Plant, Yamuna Nagar, Haryana.		Panipant Thermal Power Plant, Haryana.		Ceramic Pottery Industry, Khurja, Bulandshahr U.P.
		Slurry Mass %	Fly ash Mass %	Fly ash Mass %	Bottom ash Mass %	Fly ash Mass %
1	Na_2O	-	_	-	2.02	0.482
2	MgO	0.381	0.453	0.343	1.70	0.833
3	Al_2O_3	30.6	33.6	32.8	9.97	26.1
4	SiO_2	59.0	54.2	56.1	77.4	53.7
5	P_2O_5	0.463	1.09	0.562	0.125	0.736
6	SO_3	0.346	0.200	0.387	0.169	0.534
7	Cl	0.0586	0.0545	0.0371	0.0976	0.0406
8	K_2O	1.66	1.88	1.84	2.19	1.78
9	CaO	0.929	1.35	1.10	1.62	3.39
10	TiO_2	2.09	2.43	2.49	0.494	2.12
11	Cr_2O_3	-	-	-	-	0.211
12	Fe_2O_3	4.47	4.59	4.30	4.22	9.82
13	CuO	-	-	-	-	0.114
14	ZnO	-	0.0324	-	-	0.0658
15	SrO	0.0241	0.0401	0.0378	-	0.0591
16	ZrO_2	-	-	-	0.0357	-

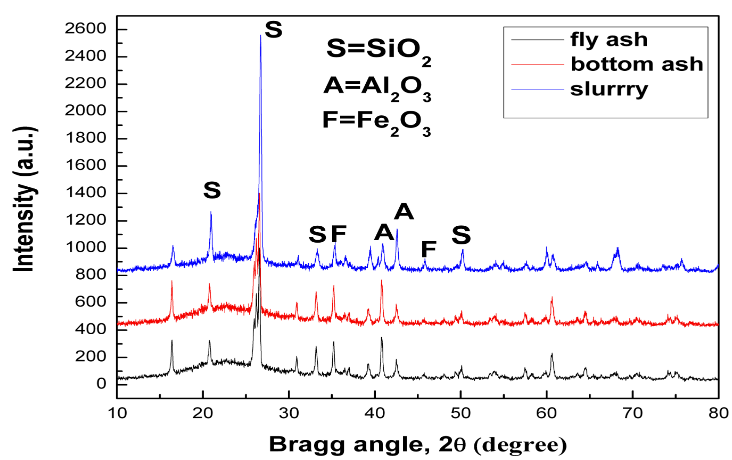

Figure 3

Conclusion

The present study has shown that the chemical composition of fly ash is not constant and varies considerably from one type of ash to another type depending on type of coal burning process in different thermal power plants. In the present analysis; using XRF technique, we observed that the major elements in all fly ash samples are Si, Al and Fe and the other Ti, P, S, Mg, Cl, K, Ca, Zn and Sr elements occur as minor constituents. As in bottom ash Si is about 77 % and in fly ash, Al is about 32 %, we propose that a study to establish the economical and technological extraction of silicon and aluminum from fly ash should be performed.

REFERENCES

1. Envis Newsletter **Vol. 2** (2005).
2. Head Water Resources, Green Building Council U.S.; http://www.flyash.com.
3. D.C Adriano, P.L.Page, A.A.Elseewi and I.Straughan, *J. Envir. Qual,* ***9*** **(3)**, 333 (1980).
4. Parisara Envis Newsletter **vol.2** No.6 (2007).
5. N.L. Misra and K.D. Singh Mudher, *Prog. Cryst. Growth Charact.Mater,* 65 (2002).
6. Z. Ustundag, O.M. Kalfa, Y. Erdog˘an and Y.K. Kadıoglu, *Nucl. Instr. and Meth. B,* **251** 213 (2006).
7. A. Kucukonder, H. Cam, E. Kucukonder, O. Sogut and J.Quant, *Spectrosc. Rad. Transfer,* **77**, 329 (2003).
8. M. Bettinelli and P. Tania, *Spectrometry X-ray Spectrum*, ***19***, 227 (1990).
9. V. Vijayan, S.N. Behera, V.S. Ramamurthy, S. Puri, J.S. Shahi and N.Singh, *X-ray Spectrom*, **26**, 65 (1997).
10. M. Ertugrul, S. Kobya and O. Dogan, *J. Radioanal. Nucl. Chem.* ***203*** **(1)**, 119 (1996).